UNIT ANALYSIS IN COMPOSITE NEURAL RECORDINGS

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ABSTRACT

We have used threshold level, sinusoidal stimuli to selectively elicit phase-locked activity from cutaneous mechanoreceptors, for the purpose of evaluating single unit activity in multi-unit peripheral nerve recordings. Each receptor is characterized by its response to a range of mechanical stimuli and by the size and location of its receptive field. This information is used to determine the number and type of units present in multi-unit recordings made with chronically implanted electrodes and to follow the presence of the units in the recordings over time. This approach can be used with any type of composite neural recording in which units can be selectively activated and classified.

INTRODUCTION

Cutaneous mechanoreceptors can be characterized by their responses to various types of mechanical stimuli and by the size and location of their receptive fields. It is possible to group receptors into several classes which possess distinctive response properties [1]. Some receptor types respond most vigorously to transient stimuli which contain high velocity or acceleration components, while other receptors are more responsive to relatively tonic stimuli, such as a sustained indentation. Additional distinctions can be made between the patterns of innervation: a single unit may innervate hairs, an area of skin between hairs, or stretch receptors in the dermis.

The differences in response properties of cutaneous mechanoreceptors provide a useful means for distinguishing the activity of single units in a multi-unit recording, and we have taken advantage of this to evaluate the amount and type of information which can be obtained from multi-unit recordings made with chronically implanted electrodes and to determine the stability of the recordings over time.

By using a sinusoidal mechanical stimulus, it is possible to elicit phase-locked firing from mechanoreceptors [2, 3], and by adjusting the frequency and intensity of the stimulus it is possible to activate a single afferent nerve fiber. This is useful in cases where repeated samples of action potentials from a single unit are needed, as when generating waveform 'templates' for use in an automated action potential classification system.

METHODS

Multi-unit signals were recorded from the radial nerves of anesthetized cats with electrodes implanted inside single fascicles. Cutaneous mechanoreceptors innervated by nerve fibers contributing to the recorded signal were activated with several types of stimuli and the resulting signal was stored on FM tape.

Areas from which activity could be evoked were identified by brushing the cat's paw with a small paintbrush or by indenting with a blunt probe. Phase locked activity was evoked from single units with sinusoidal stimuli provided by a small vibrating probe. The receptive field for the unit was determined by moving the stimulator around to determine the limits of the area from which activity could be evoked by a stimulus of moderate intensity. Receptors were classified on the basis of their responses to stimuli of varying force, velocity and acceleration and by their receptive field characteristics, as described by Horch, Tuckett and Burgess [1].

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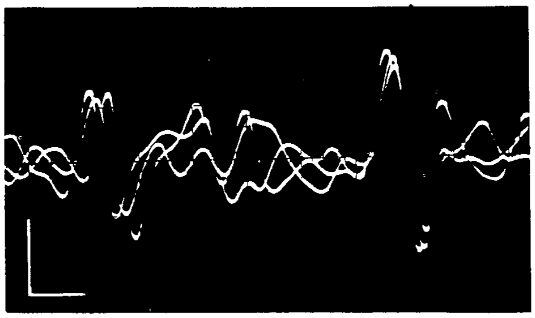

Figure 1. Three stimulus-triggered oscilloscope sweeps showing phase-locked activity in two units. Calibration: 5 µV x 0.5 msec.

RESULTS / DISCUSSION

Typically a single unit could be selectively activated by adjusting the frequency and intensity of the sinusoidal stimulus. In cases where it was not possible to isolate a single unit with the stimulus, the latency of the action potentials relative to the stimulus was generally different for different units, so it was possible to distinguish between the activity of the different units even if the size and shape of the action potentials for the units was similar. Figure 1 illustrates phase-locked activity of two units; the figure shows three stimulus-triggered sweeps across the oscilloscope screen, in which each unit fired consistently at a given location in the stimulus cycle.

We used this method to evaluate recordings made with chronically implanted intrafascicular electrodes and found that it was possible to identify the presence of individual units over several recording sessions. Figure 2 shows action potentials from two cutaneous mechanoreceptor units which were identified during experiments one month apart.

Coupling this method for determining the receptive field properties of cutaneous mechanoreceptors with an automated action potential classification system should make it possible to obtain information about the firing activity of specific receptor types and to draw conclusions about the input-output relationship between the stimulus and the evoked activity.

Although we used this technique to analyze recordings from peripheral sensory receptors, we expect that it could be applied to the analysis of any sort of composite neural recording in which it was possible to selectively activate units and characterize them with respect to their stimulus-response properties.

REFERENCES

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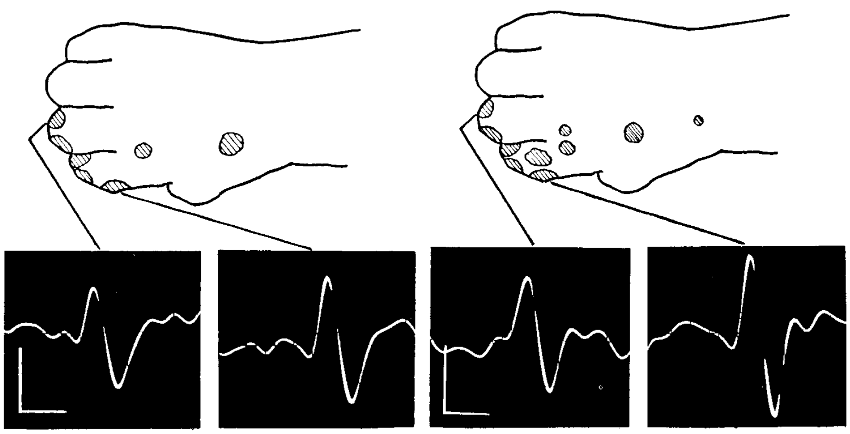

Figure 2. Left) Receptive fields of cutaneous mechanoreceptor units recorded with an intrafascicular electrode. Sample action potentials are shown for two of the units. Right) Receptive field map and action potentials for the same two units one month later. Calibration: 5 µV x 0.5 msec.